# Span



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*Although encouraged to grow his main food requirements himself, the needs of the African plot-holder in Rhodesia have so multiplied that today he often grows a surplus of grain for sale, to provide him with his other wants. Our cover photograph shows a woman sorting a fine crop of maize cobs, or mealies, the staple diet of the African community.*

*Photo: Hulton Press Ltd.*

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# Introducing 'Span'

*An important milestone in the history of this journal is reached with the publication of this issue. For, besides appearing under a new title,* Span, *it is the first to contain articles written for it by contributors outside the Royal Dutch/Shell Group.*

*This journal started life in 1949 as a technical bulletin for Shell companies marketing agricultural chemicals. Its title until the end of 1956 was* Shell Agricultural Newsletter, *then it became* Shell Agricultural News, *and its presentation was changed to that of a magazine for distribution to outside readers. Now the title* Span—Shell Public Health and Agricultural News—*has been chosen to denote the wider field which we shall cover.*

*In this issue we publish an article by a leading worker in the field of public health: we hope in the future to publish contributions from equally authoritative writers on many other agricultural and public health topics.*

*Contributions from within our own organisation will continue to appear: some will pin-point work of special interest that is being carried out in different parts of the world, and some will review wider aspects of agricultural practice.*

*Other articles may deal with subjects of theoretical importance rather than immediate practical application and we shall also hope to devote space to current questions of research and education. Our aim, in fact, will be to range as widely as possible over the fields of agriculture and public health.*

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*Readers are invited to submit contributions for publication in* Span*: those published will be paid for.*

# Agricultural Chemicals Reviewed

What were the most significant world trends in the field of agricultural chemicals in 1957? Below, we summarise those which seem to us to have been of particular importance. We shall hope to publish similar reviews of the agricultural chemical industry's progress and problems from time to time, for we believe that the way in which the industry reacts to new circumstances is of direct interest to those who use its products—whether on the farm or estate or at the research station. Such knowledge is, in fact, a prerequisite for a full understanding between producer and user.

*Insect Resistance.*—The problem of resistance to hydrocarbon compounds has undoubtedly been to the forefront during the year. It has been rightly recognised that the implications are particularly serious in the public health field, where a limited number of insect species may be exposed to insecticidal selection for periods of years over extensive areas.

In the agricultural field, however, fears that chlorinated hydrocarbon compounds have had their day have not been realised—probably because crop pests are not subjected to such rigorous selection as are those in the public health field. Any local build-up of resistant strains tends to be diluted from adjacent unexposed populations since it is presumed that the 'resistant' insects are less well adapted for survival in a 'normal' environment than the 'non-resistant'.

Furthermore, wider recognition has been given to the fact that in applying insecticides to crops such as cotton, the object is seldom the control of a single pest but rather a complex of insects, not all of which will develop the trait of resistance. Despite current work on the use of compounds whose effectiveness is negatively correlated with DDT resistance, and work on synergists which block the dehydrochlorination enzyme system of insects, there is a very strong feeling that little progress will be made towards the solution of this problem until much more fundamental work on insect physiology has been completed.

*Legislation Affecting Agricultural Chemicals.*—Governments and industry are extremely conscious of the possible hazards to man and animals that may arise from the use of agricultural chemicals. Many of these materials must, of their very nature, be poisonous, and it is necessary to ensure that when an insecticide with a long residual life is applied to edible crops, dangerous residues will not be present on the food when it reaches the table. Again, workmen applying poisonous materials in concentrated form have to be properly protected. Consequently, the information which has to be obtained on the toxicology of new materials, and on their probable residues in foodstuffs, is extensive.

When considering this data in respect of any particular new compound, the possible hazards will have to be set against the possible advantages to be gained in terms of, say, improved health or an improved standard of diet.

*Phosphorus Insecticides.*—Influenced by the ' resistance ' problem, the problems connected with obtaining approval for insecticides giving high residues on crops, and various other factors, there has been a marked transfer of effort by the agricultural chemical industry from the development of the chlorinated hydrocarbon insecticides to the phosphorus ester insecticides. As evidence of the trend, at the end of 1957 there were about 25 different phosphorus compounds being actively marketed and a further 30 under development. For comparison, there were 11 chlorinated hydrocarbon insecticides being actively marketed and very few under development.

An analysis of patents published during 1957 shows that the number relating to the phosphorus compounds was six times as great as the number relating to chlorinated hydrocarbon insecticides.

*Weedkillers.*—In the field of weedkillers little that is new appeared during the year, but some effort was evidently being devoted to developing herbicides with highly specific uses, such as the substituted phenoxy fatty acid homologues. In a generally uneventful year for weedkillers, Geigy's Simazin has shown great promise for the control of weeds on maize and sugar cane, and there has been considerable interest in new uses for Dow's dalapon.

*Fungicides.*—Zineb and captan continue to make progress in specialised applications at the expense of the older inorganic fungicides, but with the price of copper at the lowest levels for many years, it may be expected that increase in the use of the newer inorganic fungicides will be slower in the immediate future.

Perhaps the most significant inroad of recent years into the market for the older inorganic fungicides has been the widespread adoption of straight mineral oil for the control of leaf-spot disease on bananas. How far this technique will develop will depend to a great extent on the banana growing and marketing organisations, who have not, as yet, committed themselves to its general adoption.

*Soil Fumigants.*—Last year the industry showed considerably more interest in the development of nematocides and soil fungicides than hitherto, and interest in these products is gradually increasing among agriculturalists.

*Giberellins.*—The imagination of the public was fired during the year by the publicity given to the giberellins, although the practical worth of these compounds has yet to be proved.

# Using Radioactive Materials in Agriculture

*by* **Anthony Parkin**
of *The Farmers Weekly*

On a disused airfield near Wantage, Berkshire, a team of scientists, most of them young men, is engaged on work which could have an enormous impact on farming, not only in this country but all over the world. They are members of the Technological Irradiation Group set up a few years ago by the Atomic Energy Research Establishment at Harwell to find uses for the waste fission products from atomic power stations.

The new centre at Wantage is not yet completed. When it is, it will be the finest irradiation laboratory in the world.

Before going on to describe some of the work at present being carried out there, and elsewhere, let me first try to define the various ways in which irradiations can help the farmer, and explain why there is going to be so much scope in this field in the future.

When uranium is split in a nuclear power station it leaves a mass of radioactive material. This must either be suitably stored until its radioactivity has worn off (hundreds of years in the case of some elements), or used for some industrial or agricultural process. The Wantage team's job is to try to find profitable uses for these products, as storing them would prove both difficult and expensive.

There are three main ways in which radioactive materials can be used for the benefit of the farming and food industries :

First, to cause mutations in plants (and possibly animals) in order to speed the rate of improvement by breeding.

Secondly, as 'tracers' in research of many kinds, especially in the field of plant and animal nutrition.

Thirdly, to kill bacteria, fungi and insects which cause food and crop spoilage.

There are other avenues of research which do not fall conveniently under these headings, but which have not yet been fully investigated. It is possible, for instance, that certain doses of irradiation to growing plants might actually stimulate their growth.

Let us consider plant breeding first. It has been known for 30 years or so that bombardment by gamma rays, neutrons or X-rays can cause mutations. The effect appears to be that of knocking out or altering certain genes, and the technique offers a short cut to crop improvement. While no new varieties bred in this way in Britain are yet on the market, there are several promising cereal varieties under trial at the Plant Breeding Institute at Cambridge, the Guinness Barley Research Station at Warminster, and elsewhere.

The work at Wantage is aimed mainly at demonstrating the possibilities to plant breeders. One of the difficulties encountered is the tremendous volume of plant material which has to be handled in order to select any promising mutants. Of 5,000 seeds irradiated perhaps only one—and maybe none—is going to be of any ultimate use. For this reason, some means of mass selection is desirable, and that is one of the techniques being developed at Wantage. The introduction of disease resistance to otherwise good commercial varieties is thought to be one of the most fruitful fields for radiation-induced mutations, and at Wantage, seeds are irradiated and germinated by the thousand on large trays where they are sprayed with disease inoculum in order to see which survive.

Several radiation mutants bred in other countries are now being grown commercially, including a mildew-resistant barley from Germany and white mustard and pea varieties from Sweden.

One other interesting piece of work being carried out at Wantage on plant breeding involves the use of radiations to break down the barrier between incompatible species of plants. It is sometimes impossible to cross allied species (some grasses, for example) because the pollen of one will not penetrate the stigma of the other, so the pollen is being irradiated to discover whether this will provide an answer. Already, at Aberystwyth this technique has been used to

break down barriers between the rye grasses and the fescues.

The plant breeding work will be taken a stage further at Wantage when the ' cobalt 60 field ' is ready for use. This is a field with a radioactive source at the centre, round which plants and fruit trees can be grown, either exposed to the radiations or behind concrete walls for control purposes. This will enable scientists to see exactly what effect radiations at various levels have on growing plants and also enable them to produce bud mutations in fruit trees.

The ' tracer ' technique—that is, the technique of including minute amounts of radioactive isotopes as ' labels ' in experiments—has been known for some time but it is only in recent years that sufficient isotopes have become available for much research. Now scientists from all over Britain are going to Harwell for courses on the use of radio-isotopes in their work.

The technique is making possible a great deal of work which, it is no exaggeration to say, could not be carried out in any other way. Not only that : it frequently allows work to be carried out, particularly nutrition work, without having to destroy, as it were, the evidence. The animal nutrition worker can see just where the food he fed to an animal went without necessarily having to slaughter and dissect it, by adding a minute amount of radioactive carbon and using a geiger counter. Similarly, the man engaged on research into fertiliser uptake can find exactly where the phosphate went by adding a trace of radioactive phosphorus to it—he does not have to grind the leaf and analyse it. Furthermore, he can be absolutely sure that it was the same phosphate which he applied and not some already present in the soil or translocated from another part of the plant. He can even take a ' photograph ' of the position of the fertiliser in a leaf by clamping a piece of film over the surface ; the rays from the radioactive isotope will expose the film.

Fundamental work of immense importance has been, and is being, carried out at various centres in Britain : at Long Ashton, valuable work has been done on fertiliser uptake and systemic insecticides ; at the Rowett Research Institute, on animal nutrition ; at the National Institute for Research in Dairying, on milk secretion ; at Rothamsted Experimental Station, on bee behaviour.

The technique has been used successfully on insects and animals, too, for such purposes as finding out how fleas migrate from one animal to another, or how far aphids travel, or how wireworms move through the soil ; even moles have been tagged and their movements followed with a geiger counter.

Harwell now does an excellent trade in radioactive isotopes and has customers in many countries. Radioactive organic compounds are manufactured at the Radiochemical Centre at Amersham, where hundreds of thousands of pounds worth are stored. [*Continued on next page*]

*Radiation-induced mutations offer a short cut to plant improvement, but the vast majority of the mutants turn out to be useless—many of them freaks. Here are three freak Atle mutants compared with a normal ear of Atle on the left.*

PHOTO : FARMERS WEEKLY

*Mr. R. N. H. Whitehouse, who has been responsible for much of the work with radiation-induced mutations at the Plant Breeding Institute, shows the difference in height between normal Atle (background) and a short-strawed sport. It is felt that in most cases these mutants offer more scope as parent material than as varieties in their own right.*

PHOTO : FARMERS WEEKLY

*One of the workers at the Radiochemical Centre at Amersham, where radioactive organic compounds for research are prepared. The arrangement of tongs enables the most delicate work to be carried out behind the safety of a thick, transparent plastic sheet.*

PHOTO: CENTRAL OFFICE OF INFORMATION

All the uses of the by-products of atomic energy so far described are what one could call ' back-room ' uses. The application which is likely to have the most dramatic effect is the last of the three, namely, the use of radiations as bactericides, fungicides and insecticides.

There are enormous possibilities in the field of food preservation, provided certain basic difficulties can be overcome. Paradoxically, the less complex an organism, the higher the dosage of radiation needed to kill it. A human would be killed by a fraction of the dosage required to kill bacteria. The high dosages necessary to *sterilise* food tend also to spoil its taste and smell, although this might be overcome by irradiating under a vacuum or at low temperature. On the other hand, it has been found that a lower dosage will considerably improve the ' shelf life ' of the foodstuffs, with preservation of taste and smell; this is known as a pasteurising dose. Meat treated in this way, for example, has been kept for three weeks in a domestic refrigerator without turning bad.

The development of atomic food preservation would have a profound impact on world food production and marketing. Advances have been made in the U.S.A. in this field, and already large-scale feeding trials with irradiated food have been carried out. There is no chance at all of the food being radioactive.

What will probably come before food sterilisation is irradiation of potatoes and possibly onions, to prevent them from sprouting. This has reached a stage where it could be put into practice, and in the U.S.A. a machine has been designed to do the job (the cost was estimated at about 1d. a bushel for potatoes). Large-scale irradiation could prevent the difficult period between the time when the main crop of potatoes begins to deteriorate and the start of the new crop, for potatoes treated experimentally kept for 15 months without losing condition. One of the scientists at Wantage is investigating the possibilities of irradiating seed potatoes to delay sprouting, so that they could be transported to tropical countries without sprouting on the ship.

Finally, there is insect control. This can be achieved either by direct irradiation or by indirect means. The latter has been used successfully in the U.S.A. to deal with the screw worm fly on an island. Thousands of specially bred male flies were irradiated to render them sterile and then released in the area to mate with the females. It is possible that present work at Wantage may lead to the same technique being used against flour moth in this country.

It has also been proved possible to kill or sterilise insects in grain and meal by irradiation, and we may see plants set up at ports and mills in the future which will use this technique.

In this article the by-products of the nuclear power stations have been discussed. Of course, in the future farming in every aspect will stand to gain directly from the power stations themselves—in terms of cheap electricity for grain drying, lighting, pumping and even soil warming.

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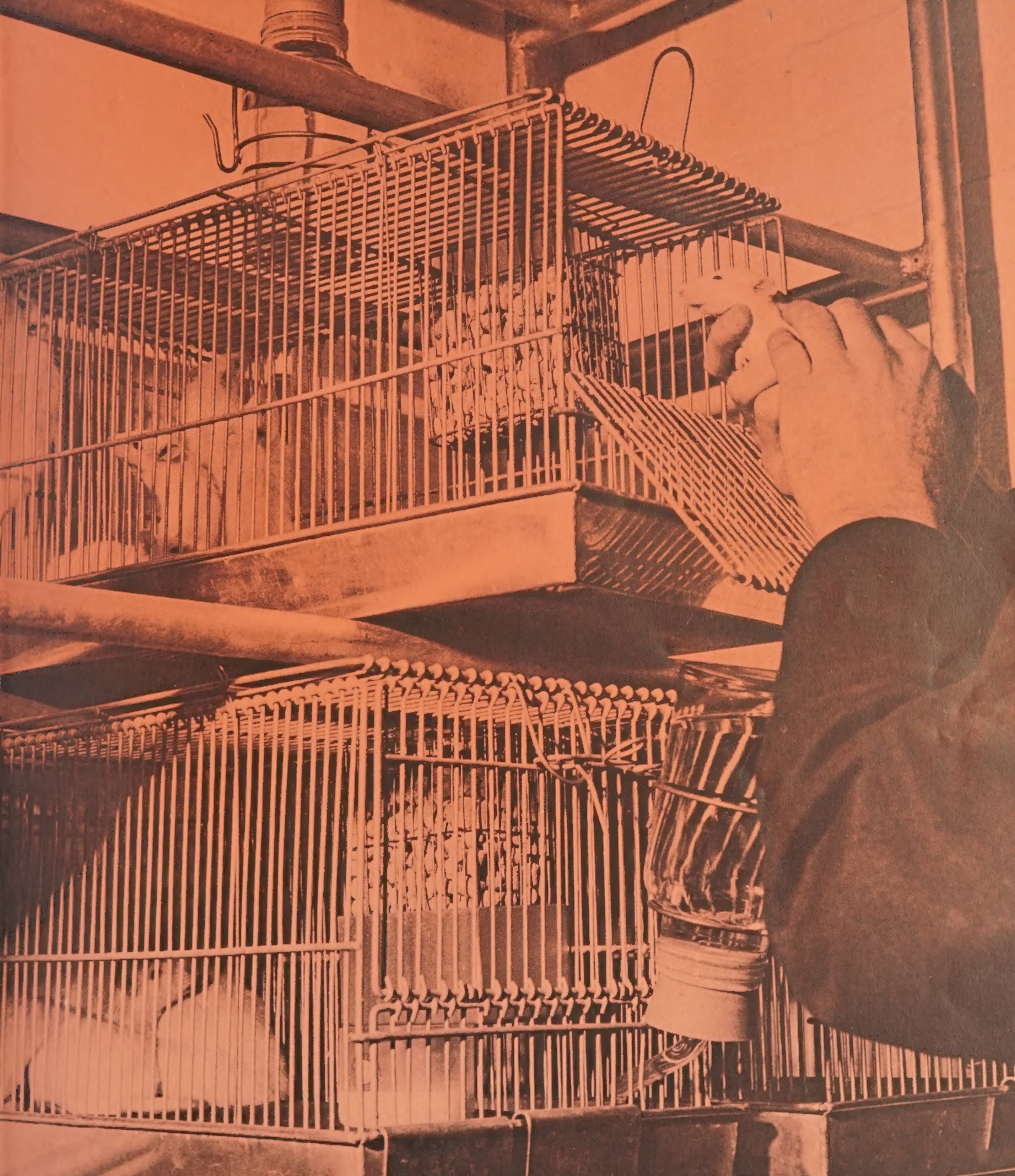
## FOR FURTHER READING

Two books which were published last year and which should prove of interest to those who wish to read further on the subject of radioactive substances in agriculture are:

*Atomic Energy and Agriculture*, edited by Dr. C. L. Comar. The American Association for the Advancement of Science; Bailey Bros. & Swinfen. 86s. (460 pages).

*Atomic Energy in Agriculture*, by W. E. Dick. Butterworth Scientific Publications. 15s. (150 pages).

The book edited by Dr. Comar consists of 22 authoritative reviews presented at a U.S.A. symposium three years ago. Mr. Dick's book is more popular in its approach to the subject.



*Some of the white rats at Wantage which are being used in feeding trials with irradiated foods to determine its effect on their growth rate, health, reproduction, length of life and other characteristics. Trials with humans have already been carried out in the U.S.A.*

PHOTO: FARMERS WEEKLY

# Insecticide resistance in disease-carrying insects

*This article has been condensed by the author from the first half of his paper, " Insecticide-Resistant Strains of Insects of Public Health Importance ", published in the* Transactions of the Royal Society of Tropical Medicine and Hygiene, *Vol.* 51, *No.* 1, *pp.* 11-36, 1957. *An article condensed from the second half of this paper will be published in the next issue of* Span.

Insecticide resistance is becoming increasingly serious in all branches of pest control. To appreciate the significance of resistance in the field of public health, one must realise the extent to which this field relies on the newer insecticides, especially in the tropics, following the achievements of the past decade.

DDT and other new chlorinated insecticides combine high activity and persistence with relatively low toxicity to man ; but above all, they are cheap and simple to apply, which has led to their use on a vast scale in poor, disease-infested and under-developed countries.

Strictly speaking, resistance is not a new phenomenon, though it has become much more prevalent in the past decade and seems, therefore, to be connected with the wide use of new insecticides. This may be due to one or more of the following causes :

(i) There may be certain weak links in the mode of action of chlorinated synthetic insecticides, which permit the development of biological defence mechanisms ;

(ii) The persistent residues of these insecticides may impose a type of selection on the insect population, which especially favours the elimination of the susceptible and survival of the resistant ;

(iii) The use of insecticides has been on an unprecedented wide scale and therefore the populations of pests exposed to selection have been bigger than ever before.

A circumstance that seems to support this last point is the high proportion of cases of resistance among insects of public health importance. Thus, WIESMANN (1954) lists 37 examples of possible resistance in pests of hygienic importance as compared with 25 examples from the far more numerous pests of agriculture, forestry and stored products. It is likely that insecticidal campaigns against disease-carrying insects have been more extensively conducted (often on a national basis) than measures against other pests. Incidentally, Wiesmann's lists call attention to the special prominence of certain orders of insects, in the development of resistance. Two-thirds of the hygienically important examples belong to the order Diptera ; and nearly half the agricultural cases belong to the Hemiptera.

In 1946, soon after DDT became available for wide use, resistant strains of the common housefly emerged. Since then, signs of resistance have appeared in a stealthily growing number of species of public health importance. In the last year or so, some serious disease vectors have been added to the list and this has given rise to considerable anxiety. Even in 1956 Dr. Candau, Director-General of the World Health Organisation, issued a warning that reports of resistance had arrived from no less than 32 nations, and between 20 and 30 different insect pests of public health importance were involved. It is becoming evident that to proceed with our plans, and even to hold the ground we have won, we must re-think our strategy of attack against insect disease vectors.

**The Housefly :** It is well known that the housefly (and its sub-tropical and tropical varieties) are, nearly everywhere, more or less resistant to all the newer synthetic chlorinated insecticides. It might be argued that this is more of a grievous disappointment than a disaster, for the housefly is not one of the most important disease vectors. Nevertheless, flies do carry disease ; and before the residual insecticides had become ineffective, WATTS and LINDSAY (1948) had shown how conveniently DDT could be used to reduce shigellosis in fly infested villages. The failure of

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chlorinated insecticides is felt keenly in hot dry climates. Pyrethrins can still be used, but they must be used frequently and are too expensive for wide application.

A more practical measure against resistant flies is the use of organo-phosphorus insecticides. Several years ago, laboratory tests were begun to investigate the chances of resistance developing against these compounds. The results were moderately encouraging, for some 100 generations of selection only produced a mild degree of resistance (CHADWICK, 1954). Similar levels of resistance have appeared recently in the field in two areas where organo-phosphorus compounds had been used for three to four years for practical control in dairy barns. One place is Florida, where these insecticides have been used as poison baits (LINDQUIST, 1956); the other is Denmark, where they have been employed as residual treatments (KEIDING, 1956). Unfortunately, although the levels of resistance are low compared with those shown towards chlorinated insecticides, they are beginning to prevent effective control. Perhaps it is a little early to abandon hope of using organo-phosphorus insecticides for fly control; but the chlorinated compounds seem to have no future for this purpose.

**Anopheline Mosquitoes:** In 1956, three new cases of resistance among malaria vectors were reported and two former claims confirmed. Despite these ominous warnings, the over-all situation is not entirely gloomy. Anopheline mosquitoes were some of the first insects to be systematically attacked by residual insecticides and many have been under continuous control with DDT for eight to 10 years. Years of house spraying have evidently not changed the susceptibility of *Anopheles atroparvus* in Spain, Sardinia and Italy, and of *A. culicifacies* in Ceylon and India, of *A. pseudopunctipennis* in Mexico or of *A. darlingi* in British Guiana. Nevertheless, where resistance has developed, it is sufficiently serious to prevent control by the insecticide concerned.

*Anopheles sacharovi* in Greece.—DDT has been used in a national antimalarial campaign in Greece since 1946, both as a residual house spray and for aerial larviciding. Malaria was reduced from the pre-war incidence of one to two million cases a year to some 10,000 to 15,000 per year. The first signs of resistance were reported to W.H.O. in December, 1951, and published later by LIVADAS and GEORGOPOULOS (1953). At present, resistance of *A. sacharovi* appears to be widespread in the country, judging from tests in several localities. In recent years, chlordane and dieldrin have been used to some extent and *A. sacharovi* has become resistant to them also (GEORGOPOULOS, 1954; BUSVINE, 1956). According to field observations, *A. maculipennis* and *A. superpictus* have also lost their susceptibility to DDT; but this has not been confirmed.

In spite of widespread prevalence of the important vector, *A. sacharovi*, owing to resistance, there has not been an appreciable rise in malaria. The disease has never been extinguished; it continues to smoulder on in a number of villages, especially in the north-western Peloponnese, in Epirus and in Macedonia and Thrace (BELIOS, 1955). Various reasons have been advanced for the " anophelism without malaria " which exists in many areas. Perhaps the partial immunity to malaria persists longer than was supposed. Perhaps the gametocyte carriers are too few and do not travel about. Alternatively, the selective effect of DDT has produced a more zoophilic race. I observed that *A. sacharovi* tends to rest more outside houses than formerly; but this may be due to the irritant effect of DDT, which may persist even if the mosquitoes are more resistant.

*A. sacharovi* in Lebanon.—DDT has been widely used in the Lebanon since 1947. In 1954, Garrett-Jones and Gramiccia reported evidence of resistance in a village on the Syrian border. I myself confirmed this in 1955; but the resistance was not of a high order and does not yet seem to prevent adequate control.

*Anopheles sundaicus* in Java.—In 1952, two residual

*An adult male anopheline mosquito* (Anopheles stephensi).

spraying campaigns were initiated in Java. (Prior to that time there had been an indefinite amount of control by larvicides containing DDT.) Housespraying against the principal vector, *A. sundaicus*, began in a W.H.O. scheme in the south, along the coast near Tjilatjap ; and at the same time a programme directed by I.C.A. (F.O.A.) began in the north, near Djakarta and Tjirebon. Results were not very satisfactory. In the Djakarta area there was no decline in malaria. In the south, there was a fall in malaria indices in 1953 in both treated and untreated areas; but both rose substantially in 1954. It appears that one reason for these failures is that *A. sundaicus* is very readily irritated by DDT and tends to avoid contact with treated surfaces. Apart from this, however, resistant strains were discovered near Djakarta and Tjirebon (Crandal, 1954) and later high resistance was also proved at Semerang, also on the north coast (Davidson, quoted by Busvine, 1956). No evidence of DDT resistance has been reported for other local anophelines, such as *A. subpictus* or *A. aconitus*. The *A. sundaicus* were shown to be still susceptible to dieldrin and gamma BHC and the former has been employed since 1954, so far with success.

*Anopheles gambiae* in Nigeria.[1]—In Western Sokoto (Northern Nigeria) a malaria control pilot project, depending on residual spraying, was initiated in June 1954. Some 300 square miles were allocated to treatment with dieldrin, mainly at 25 mg./sq. ft. After three sprayings at six-monthly intervals had been completed, evidence of resistance was found and confirmed by measurements of susceptibility of mosquitoes from treated and untreated areas (Elliott and Ramakrishna, 1956). Subsequently, a colony of these resistant mosquitoes was established at the Ross Institute in London. This colony was found to be enormously resistant to dieldrin and similar insecticides, moderately resistant to gamma BHC, but not significantly resistant to DDT (Davidson, 1956a). Further studies in London (Davidson, 1956b) revealed a simple Mendelian basis of inheritance of resistance in this mosquito. It seems very likely that the comparatively low level of resistance, registered first in the field, was due to the heterogeneity of the population (mixed susceptible, resistant and heterozygotes) ; whereas the London colony seems to be a pure homozygous resistant strain.

*Anopheles quadrimaculatus* in U.S.A.—DDT has been widely used in south-eastern U.S.A., for control of *A. quadrimaculatus*, since 1946. At one point it seemed that DDT-resistance had developed in the Tennessee Valley (Kruse *et al.*, 1952) ; but subsequent investigations showed that the failure of the DDT was due to causes other than resistance (Hawkins and Hall, 1954).

An indication of another type of resistance was obtained in 1953, when heavy applications of dieldrin failed to kill *A. quadrimaculatus* larvae in Mississippi. This year, definite proof has been obtained of high resistance to dieldrin, chlordane and gamma BHC, in this region ; however, the tests show normal susceptibility to DDT (Mathis *et al.*, 1956). It appears that this resistance has developed as a result of contamination of the breeding grounds during aircraft dusting with insecticides against cotton pests. The seriousness of this particular incidence of resistance is mitigated by the virtual eradication of malaria from the U.S.A. in recent times.

*Anopheles stephensi* in Saudi Arabia and India.—DDT house spraying was first used against *A. stephensi* in Saudi Arabia in 1947, by the Government, in collaboration with the Arabian American Petroleum Company. About 250,000 people live in the treated localities, which were sprayed in alternate years, with the resulting improvement in malaria. In 1954 and 1955, however, Drs. Daggy and Peffly of ' Aramco ', reported an increase in malaria and the appearance of *A. stephensi* in DDT-treated houses. They suggested the possibility of resistance ; and this was con-

[1] Resistance in *A. gambiae* has more recently been reported in other parts of West Africa, but not, so far, in East Africa.

*An adult house fly*
(Musca sp.).

firmed by Mr. G. Davidson, who visited the country in November, 1955. He found, however, that the mosquito was normally susceptible to dieldrin and it is understood that this insecticide is now being used for house spraying in Saudi Arabia.

DDT-resistant *A. stephensi* have also appeared locally in southern India.

**Culicine Mosquitoes :** The first mosquitoes to show signs of insecticide resistance were various culicine species in the U.S.A., which were being sprayed from the air with larvicides, because of the nuisance of their bites. They include the following :

(i) *Aedes sollicitans* and *A. taeniorhynchus*, which breed in salt marshes in Florida (Deonier and Gilbert, 1950).

(ii) *Aedes nigromaculis*, *A. dorsalis* and *Culex tarsalis*, which breed in irrigation water, in California (Bohart and Murray, 1950 ; Gjullin and Peters, 1952).

(iii) *Psorophora confinis*, which breeds in rice fields in Mississippi (Mathis *et al.*, 1955).

Apart from these culicines, there have been scattered reports of resistance in members of the *Culex pipiens* complex, and, more recently, in *Aedes aegypti.* The last two cases will be considered in more detail because of their greater importance as disease vectors.

*Aedes aegypti* in Trinidad.—Since this mosquito is so endophilic in habit, it has in many places come in contact with DDT residues which were primarily intended for killing malaria vectors. The result has usually been very satisfactory. Thus, the anti-anopheline campaign in Greece, Mauritius and British Guiana was effective in eradicating *A. aegypti* from these countries. Pinto Severo (1954) points out that anti-anopheline campaigns have simplified the task of eradicating *A. aegypti* from central and southern America.

A very different story appears in the reports of the Medical Department of Trinidad. In this island, regular house spraying with DDT had been done for a number of years as an antimalarial measure, with fairly satisfactory results.

In spite of this, a high incidence of *A. aegypti* was noticed in several areas in 1950. Limited campaigns against this mosquito were conducted in 1951 and 1952 in the densely populated areas near Port of Spain, using DDT as a larvicide. This gave control, but no promise of eradication, and when a few cases of yellow fever occurred in 1954, the scheme was greatly enlarged to cover the whole island. However, DDT was found to give disappointing results even at a dose of 1 p.p.m.

Following the failure of DDT anti-larval treatments in the field, laboratory colonies were started in Trinidad and experiments proving high resistance to DDT were later confirmed by tests on a sub-colony at Savannah, Ga., U.S.A. (Brown and Perry, 1956). So far, there is no resistance to dieldrin or gamma BHC, which are still suitable for control measures.

*Culex pipiens* complex.—*Culex fatigans.* Reports of the first tests of DDT as a residual house spray, in different parts of the world, all agreed that *C. fatigans* is a mosquito with high natural resistance to this insecticide. Treatments which killed high proportions of the local anophelines produced only low mortalities (10–30 per cent.) in *C. fatigans.* (cf. Giglioli, British Guiana, 1946 ; Wharton and Reid, Malaya, 1950 ; Davidson, Kenya, 1952). This initial low susceptibility seems to have been decreased even further by residual spray programmes. Thus, there is evidence of locally enhanced resistance to DDT, shown by tests with larvae, in Reunion (Hamon and Dufour, 1954) and in tests with adults near Delhi (Pal *et al.*, 1952).

Since DDT gave poor results against *C. fatigans*, various field workers have used BHC or dieldrin, which initially

*An adult bed bug* (Cimex lectularis).

gave good results. However, after about two years' use of BHC as a larvicide, strains resistant to BHC and dieldrin were developed in areas in South India (RAJAGOPALAN *et al.*, 1954) and Malaya (REID, 1955). The degree of resistance was moderate, being of the order of a sixfold increase in India and a tenfold increase in Malaya; however, it was enough to affect control measures. Both authors found that when they reared these strains in the laboratory they gradually lost their enhanced resistance.

Resistance to dieldrin in *C. fatigans* would seem to be particularly unfortunate, since CHARLES (1954) has shown that combined spraying and larviciding with dieldrin can virtually eradicate this mosquito, which, of course, is the classical vector of *Wuchereria bancrofti*.

**Lice of Man:** Throughout this section, the lice referred to are the body-louse form, *Pediculus humanus humanus*. There is no evidence of resistance in the head-louse form, *P. h. capitis* nor in the crab louse, *Phthirus pubis*.

The part played by DDT dust in terminating the 1943 typhus epidemic in Naples is well known. Within a few years after the war, similar successes in checking typhus were obtained in Transvaal, Nigeria, Mexico, Chile and Spain; while relapsing fever epidemics were quelled in Tunisia and Kenya (SIMMONS and UPHOLT, 1951). The first failure of DDT to control lice occurred in P.O.W. camps in Korea; and soon afterwards experiments proved the existence of a high level of resistance (HURLBUT *et al.*, 1952). Similar observations were made in Japan (KITAOKA, 1952; BARNETT and KNOBLOCK, 1952). A strain of lice collected in Cairo in 1950, and tested later in England, was found resistant (BUSVINE, 1953) and further evidence of resistance was later obtained in other parts of Egypt (HURLBUT *et al.*, 1954).

The present position seems to be that while DDT is still quite satisfactory for controlling lice in most places, it appears that failures might occur in regions outside Europe, so that it cannot be guaranteed as a universal anti-louse measure. So far, gamma BHC dust would be a reliable substitute nearly everywhere, though there are ominous suggestions of incipient resistance. Pyrethrum powders remain as the final line of insecticidal defence against louse-borne epidemics.

**Bed Bugs:** House spraying with DDT has enormously simplified the task of destroying bed bugs in old houses. Most of this work has not been published, but KEMPER (1952) describes the successful results obtained in Berlin.

The first record of failure came from Hawaii in 1948 and subsequently reports of resistance have come from many countries, including Greece, Italy, Israel, U.S.A., the Belgian Congo and China. In addition, *Cimex hemipterus* appears to have become resistant in Hong Kong, Formosa and Singapore.

It is difficult to make general comments on the situation, as the data are so meagre, but it may be noted that the trouble seems to have occurred in the warmer regions of the world. So far, the resistant bugs in Hong Kong and Singapore appear to be normally susceptible to gamma BHC and dieldrin, but those in Israel are now resistant to all the new chlorinated insecticides.

**Fleas:** In the period between 1944 and 1948, DDT dusts used against fleas, substantially reduced murine typhus in parts of U.S.A. and checked plague outbreaks in Dakar, Haifa, Ngamiland (South Africa), Peru and Ecuador (SIMMONS and UPHOLT, 1951). Subsequently there has been a considerable number of reports of resistance, based on field observations. KILPATRICK and FAY (1952), referring to the summer of 1949, remark that ' in several instances high populations of the cat flea *Ctenocephalides felis* persisted even after three applications of 5 per cent. DDT pyrophyllite dusts to infested premises. With the use of 5 per cent. chlordane dusts, the infestations dropped markedly or were completely eliminated '.

*Dorsal view of a female American cockroach* (Periplaneta americana L.).

VERA (1953) states that DDT dust was of great value for anti-plague flea control in Ecuador for several years after 1945; but in 1950 failures were observed in two localities. The following species of fleas survived after thorough treatments, which should have been effective: *Pulex irritans*, *Nosopsyllus londiniensis*, *N. fasciatus*, *Rhopalopsylla claviculus*, *Xenopsylla cheopis* and *Polygenis* sp.

The question of DDT resistance in fleas is nowhere backed by experimental proof nor even, in most cases, by documented field observations. The series of reports of failure of DDT in the field is, however, disquieting.

**Cockroaches:** It seems that cockroaches have a natural low susceptibility to DDT and for some years it has been the practice to attack them with other insecticides, such as gamma BHC or chlordane. Failure to control *Blatella germanica* with chlordane has been observed in parts of Texas since 1951. Laboratory tests revealed a high level of resistance to chlordane and dieldrin and some increased tolerance of gamma BHC and DDT (HEAL *et al.*, 1953; FISK and ISERT, 1953). So far, it is possible to obtain satisfactory control of these insects with a mixture of malathion and perthane (LAAKE, 1955).

*To be concluded.*

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# *How dangerous are Agricultural Chemicals?*

*by* **P. C. M. Comins,** *The Shell Petroleum Co. Ltd.*

By the very nature of the work they perform, agricultural chemicals must be toxic to either the plant or the animal kingdom. It is often important that their toxicity should be selective. For instance, it is desirable that insecticides kill only the harmful insects and leave the natural enemies or predators of these harmful insects untouched. Again, most weedkillers have to be selective in their action in order not to affect the crops in which the weeds are growing.

Selectivity of action is difficult to achieve and inevitably agricultural chemicals are toxic in some degree to man. As a group, the insecticides are probably the most dangerous, since there seems to be a broad correlation between insecticidal efficiency and toxicity to humans.

The hazards arising from the use of agricultural chemicals can be divided into three main categories :

Hazard to the applicator ;
Hazard to the consumer of the crop ;
Hazard to wild life.

**Applicator :** In agriculture, the applicator or spraying operator is generally exposed to a pesticide for only a short time and for only short periods in any one year. There are exceptions of course—particularly men employed by agricultural contractors, who usually spray the same compound for much longer periods than the ordinary farmer or his men. It is significant that most of the deaths caused by dinitro-ortho-cresol (DNOC), when used as a weedkiller in Great Britain, occurred among contractors' workers.

Workers applying chemicals in the field are warned of the dangers involved by the handling precautions which are always printed on the label of the container, and in descriptive leaflets. In many countries these precautionary labels have to be submitted for official approval, and in addition the conditions of use of many of the more dangerous compounds are strictly regulated. Thus, in Great Britain the more toxic compounds are included in the Agriculture (Poisonous Substances) Regulations, which stipulate the conditions under which they may be used and the protective clothing and handling precautions which must be observed.

Deaths or illness caused by pesticides form only a minute proportion of the total number of accidents occurring on farms. Many of these result from children or animals gaining access to dangerous poisons ; many others from products being transferred on the farm from their original containers into unlabelled containers. Such accidents can easily be avoided if the buyer recognises the necessity for reading and following the precautions advised by the manufacturer.

In the public health field, insecticides are widely used for the residual spraying of houses to kill the insect vectors of diseases such as malaria, filariasis and chagas disease. Here, the sprayers are faced with prolonged exposure and the risk of cumulative effects becomes important. The World Health Organisation, which is responsible for technical advice to governments throughout the world, and particularly for the internationally assisted malaria control and eradication schemes, has drawn up its recommendations for the protection of spray operators engaged in residual spraying with insecticides. These were published during 1956 in the W.H.O. report, *Toxic Hazards of Pesticides to Man.*

**Consumer :** The risk of dangerous residues remaining on treated crops, and the consequent health hazard to the public, has in some countries led to regulations which either specify the minimum interval between last application of the pesticide and the date of harvest or, alternatively, an allowable limit or tolerance for the pesticide on any particular crop.

It is significant that acute poisoning caused by pesticide residues has never been recorded. Some people, however, still feel that the increasing use of chemicals on the land is causing slow but progressive deterioration in the general health of the public. This opinion is not backed by any scientific evidence and is usually only voiced by extremists. But this is not always the case ; for instance, 400 doctors last year signed a letter in the *Lancet* (a leading British medical journal) condemning the increasing use of agricultural chemicals and recommending a return to older and more ' natural ' methods of farming.

Vague allegations of slow deterioration in the health of the public are, of course, difficult to disprove but nevertheless there is a great deal of evidence to refute them. A good example is the investigation carried out by Dr. W. J. Hayes, of the United States Public Health Service, in which volunteers from U.S. prisons were fed large quantities of DDT for long periods without any deleterious effects on their health.


*Poisonous chemicals have to be adequately labelled, as exemplified by this drum of Shell DNOC Weedkiller.*

DDT, which is still the most widely used insecticide, occurs in the normal diet—analysis of restaurant meals in the U.S.A. gave an average DDT content of 0.31 p.p.m. Conclusive evidence of the absorption of DDT by people not occupationally exposed to it was provided by an analysis of human fat from otherwise healthy people ; an average of five p.p.m. DDT was found.

Another significant investigation was made by Richard Fowler, of the U.S. Public Health Service, who made a comprehensive survey of school attendances, mortality records, hospital admissions and similar statistics in the cotton growing region of the Mississippi delta, an area in which modern pesticides have been used on an extremely intensive scale. He found no evidence that pesticides were the ' direct or indirect cause of any chronic disease or a contributing cause in diseases generally recognised as having other etiologies '.

Many of the compounds used in agriculture are highly persistent and will remain on treated surfaces for considerable periods, though others, such as Phosdrin, disappear extremely rapidly. Before any product is marketed, an extensive series of field tests is carried out to determine the extent of the residues found at harvest on the crops on which the pesticide may be used. From the results of the toxicological tests, which will already have been performed, it is possible to judge whether the residues found at harvest represent a hazard to consumers or not.

*It is generally considered that the minimum protection required to safeguard the health of the public is a safety factor of 100 times the minimum dose liable to cause any ill effects in long-term feeding tests with the most susceptible species of laboratory animal.*

These residue studies are one of the major expenses in developing a new agricultural chemical, and may account for as much as one-quarter of the total cost of development of a new insecticide.

**Wild Life :** Little is known about the overall effect on the natural flora and fauna of the increasing quantities of chemicals which are being applied to the land. Generally speaking, it appears that the direct effect of chemical sprays and dusts on wild life is negligible in comparison with the mortality which occurs naturally, but long-term changes in animal and plant populations, due to alterations in the ecological balance of the countryside, may be more important.

It is worth noting that agriculture itself is the biggest single factor in altering the ecology of the countryside and that operations such as grass-cutting or the removal of hedgerows have a far more harmful effect on wild life than the use of chemicals.

**Government Legislation :** Governments, as guardians of public health, are paying increasing attention to the use of toxic substances in agriculture or in connection with the storage of food. The United States have probably gone further than any other country, and their legislation, which can involve manufacturers in considerable development expenses, is often regarded by other governments as the pattern on which regulations should be modelled.

Under the Miller Amendment to the Food, Drug and Cosmetics Act, firms have to submit comprehensive residue and toxicity data to the Food and Drug Administration (F.D.A.) before they can market any pesticide. Prior justification on the grounds of economic necessity has to be obtained from the U.S. Department of Agriculture. Application is then made to the F.D.A. in the form of a petition, which gives detailed toxicological data, shows that satisfactory analytical methods exist, and gives detailed residue data obtained under varying climatic and soil conditions for the crops for which marketing approval is required.

As the next stage, the F.D.A. decide on permissible limits, or ' tolerances ', for residues of the pesticide on the different crops. The tolerances established are not the highest limit which the F.D.A. considers safe, but are set at the lowest level consistent with adequate control of the

*The estimation of pesticide residues on crops is an important step in the development of new agricultural chemicals. Here a worker at Woodstock Farm—Shell's U.K. agricultural experimental station—is carrying out a chlorinated hydrocarbon estimation.*

pests involved; thus toxic pesticides are sometimes given higher tolerances than less toxic products. Ignorance of this fact has often led to confusion in other countries in which the relative safety or danger of using any particular insecticide tends to be judged by the tolerance granted by the F.D.A.

In Great Britain the pattern has been somewhat different. A Government working party, under the chairmanship of Professor Zuckerman, was established to consider the hazard from the use of agricultural chemicals. As a result of their first report, an advisory committee was set up to decide on voluntary user recommendations for agricultural chemicals. This was gradually developed and amplified until in May, 1957 a voluntary Notification and Clearance Scheme was introduced. Under this scheme, firms are requested to submit comprehensive residue and toxicological data on their products to the advisory committee. The committee then announce the precautions they consider necessary and request distributors to include these on their labels.

As in the U.S.A., the consumer of treated crops is protected from dangerous residues by the establishment of a safe interval between the last application and the date of harvesting, but not by laying down a residue tolerance, which is done only in the U.S.A.

Before any new compound can be introduced to the world market a very considerable amount of information must be obtained to establish its safety. The cost of development can easily run up to £500,000, and on an average half of this will have been spent on residue and toxicity studies and on associated expenditure, such as the development of analytical methods. The bulk of the other expenditure is required for proving the biological effectiveness of the product in the field.

In introducing new materials, the agricultural chemical industry recognises its responsibility in providing the necessary data to establish the fact that its products can be used with safety. It is important, on the other hand, that governments recognise that such work is expensive and that its cost must be included in the selling price. They ought, therefore, to be prepared to accept reasonable limits on the amount of data required.

In an attempt to reduce development costs, the chemical industry is endeavouring to obtain as much standardisation in government legislation as is possible, with acceptance of the principle that residue and toxicity data obtained in one country would be acceptable elsewhere. Achievement of these two aims would mean that the safety of new chemicals would be thoroughly examined and, at the same time, they would become available to the user in as economical and speedy a manner as possible. These benefits would be passed on to the public in two ways: firstly, by lower costs of production leading to lower prices, and secondly, by greater assurance of the safety and nutritive value of foodstuffs on the market.

*Precautions are necessary when applying poisonous substances to crops. Here, a field of peas is being sprayed with DNBP, which is toxic to humans. Note that the tractor driver is protected by an enclosed cabin, and that, although not strictly necessary while driving in the cabin, he is wearing a mask as additional protection.*

*An adult Mediterranean fruit fly* (Ceratitis capitata)—*greatly magnified.*

# Control of the Mediterranean Fruit Fly in Israel

*by* **R. Oren,** *Shell Chemicals Distributing Co. (Middle East) Ltd.*

The Mediterranean fruit fly (*Ceratitis capitata*, Wied.) is one of the most important fruit pests in the Near East. It probably originated in Equatorial Africa or in western North Africa, and has spread during the last 100 years to many areas. Besides the Mediterranean region, it is now prevalent in most African countries, as well as in Australia, Brazil, Argentina, the Bermudas, the Hawaiian islands and elsewhere.

It is not known when the fruit fly reached Israel. In 1904, however, infested oranges were found and the insect was seen throughout the whole country and over-wintered as an adult. Climatic conditions in the country and the great number of host plants encourage quick development of successive generations, and as a result fruit growers suffer heavy losses.

Apricots and peaches are most severely damaged, apricots being attacked at the beginning of the ripening period. Before this they are protected by an excretion of gum in the oviposition hole; the eggs are enveloped by this gum and die.

All ripe fruit not treated with insecticides is attacked, as well as 25–40 per cent. of the half-ripe fruit: control measures are therefore essential. Peaches are commonly covered with paper bags to prevent fly stings and to obtain an improved colour, and so long as this means is the only control method, the crop cannot be grown on a large scale. Although peaches and apricots are the most expensive canned fruits, they are in great demand, and if an efficient and economic control method could be found, it would be possible to develop a high quality preserved food industry in Israel, both for the home market and for export.

Up to 25 per cent. of the plum crop is infested, some varieties being more susceptible than others, but since plums ripen very quickly, and picking takes only a short time, there is almost no economic damage.

Unripe apples and pears are attacked by the fly, since

there exists no natural defence mechanism against it. Usually 40–80 per cent. of pears, 25 per cent. of apples and 60–80 per cent. of quinces are infested, if no control treatment is given. Since some fruit orchards are regularly treated until harvest time against the codling moth, with sprays of DDT, cryolite and lead arsenate, special treatment against the fly is not necessary.

Infestation of figs and guavas reaches 100 per cent. and in commercial orchards basic control methods have to be carried out. With the expansion of guava areas in Israel for consumption on the local market, it will become necessary to develop control methods which will guarantee the supply of clean fruit to the consumer.

Economically, citrus (orange) is the most important crop attacked. The larger part of the crop is of the Shamuti variety (Jaffas), which is the most important variety for export (about 7 million boxes were exported in 1957). Fortunately, this variety is not attacked under normal conditions—i.e., when winter starts in November and ends in March.

During the autumn months—September and October—the activity of the fly reaches its peak, but during this period the Shamuti fruit is still not ripe and the excretion of gum by the green fruit causes 100 per cent. destruction of the fly eggs. Picking of Shamuti ends in March, before the spring activity of the fly begins. Nevertheless, every few years, when autumn is prolonged or the winter is short and warm, there may be a strong attack of the fly even on the Shamuti variety, and widespread control measures are necessary.

The early (October/November) ripening varieties such as grape-fruit, clementines and tangerines, Washington Navel and others of lesser importance are usually attacked even in normal years, and the Valencia variety, which ripens in April, is exposed to the spring attack of the fly. According to GREENBERG, a serious attack may be expected once every three seasons on the average for Shamuti as well as for Valencia.

**Quarantine regulations:** During the last few years, some countries, fearing that the insect would adapt itself to their climate, have tightened their quarantine regulations for the import of citrus fruit infested by fruit fly. There were even cases when whole shipments were rejected because they were found to be infested. In Israel, fumigation with ethylene dibromide gas was used to control eggs and larvae which had infiltrated into the boxes in spite of selection, but this method did not meet the country's needs, since complete control was not obtained without causing injury to the fruit itself.

The Citrus Marketing Board does not permit the shipment of fruit infested with fly larvae, and as citrus exports are essential to the economy of the country, they have, in co-operation with the Israeli Technology Institute in Haifa, and the Agricultural Experiment Station in Rehovoth, investigated other methods of control, particularly immersion.

Immersion at first proved unsatisfactory and the Shell Chemical Co. (Middle East) Ltd. was asked by the C.M.B. to help in solving this problem. After prolonged research and experiments in the laboratory and central packing houses of the C.M.B., they succeeded in developing a cheap and effective method of immersion in an EDB solution.

**Biology of the Mediterranean Fruit Fly:** Climatic conditions, and the fact that fruit ripens in Israel from early spring until late autumn, enable the fly to be active during almost the whole year throughout the country. In the Jordan Valley, where temperatures are relatively higher than in other agricultural areas, the number of generations reaches eight per year, with the possibility of a ninth generation; in the coastal plain, the number is at least six and sometimes more.

Three to four days after the flies emerge from the pupa, they copulate. When the temperature is high—about 30° C. (86° F.)—the female is able to lay eggs four days after emergence. At lower temperatures, the pre-oviposition period may be up to 13 days, and at temperatures below 15–16° C. (59–61° F.) the female is unable to lay eggs. On the coastal plain, where almost all the citrus orchards are concentrated, suitable oviposition temperatures occur in many months of the year, but temperatures are normally too low during the winter (December–March), and only one generation develops from eggs laid during the autumn. This generation emerges at the end of February or the beginning of March, and its life cycle takes about two months, because of the relatively low temperatures at this period.

During the spring, the main host of the fly is citrus, especially the Valencia variety. The second generation

*Pupae of the Mediterranean fruit fly.*

*A peach damaged by larvae of the Mediterranean fruit fly.*

appears in the middle of May and if no suitable host, such as Valencia, is available, the female is able to wait and oviposit later on during June on apricots and early pears. This generation is very large in numbers and may cause heavy damage to stone and prune fruits. From May till the middle of September, five generations are raised ; on average, each takes about 25–30 days to mature, and overlapping occurs, which aggravates the intensity of the attack. The last generations, those of mid-September to October, attack early citrus fruits, tangerines, clementines, Washington Navel, and also early grape-fruit in the valleys.

To summarise : the fly starts to attack Valencia fruits in spring, changing to apricots and early pears at the beginning of summer. Later on it attacks plums, peaches, apples, and cactus fruits ; and in autumn, guavas, tangerines, mandarines, grape-fruit and Shamuti. During the last few years appreciable progress has been made towards limiting the host factor by national organisation of the planting areas, and this is taken into consideration when planning new orchards.

**Damage :** The female lays an average of 250 eggs in batches of four to six in small holes bored in the soft parts of the fruit. After a time, the position of these holes can be distinguished by a change in colour around the periphery. The larvae hatch from the eggs in a few days, develop in the pulp of the fruit, and then fall to the soil, where they pupate. After the larvae have left, a hole remains where secondary pests such as vinegar flies and fungi may enter. The fruit either rots on the tree, and then falls off, or becomes inedible during its journey to the consumer.

**Control :** Efficient control of the fruit fly has been the subject of research for many years in all the countries which suffer from this pest. In most areas, no possibility of eradication exists, and when it does, the cost is enormous. For example, the successful 1929–30 campaign in the United States cost 7 million dollars. [*Continued on next page*]

The control of the Mediterranean fruit fly in Israel is based today on the use of synthetic insecticides, which are, however, too expensive for some fruits. Discussions are in progress on the economics of fly control in apricot and peach orchards, and research with new materials and methods is continuing.

In citrus orchards, the Citrus Marketing Board insists on the grower using control methods in the event of an attack, even if its intensity does not justify the treatment, and this prevents the export of even slightly infested fruit. With pome trees, the fly is controlled by the continuous treatments applied against the codling moth. Generally, control markedly increases growing costs, and is not economic when the market is saturated at harvest time and fruit preservation is impossible.

The simplest way to prevent fly attacks is by covering the fruit with paper bags, and this was the normal method employed in peach orchards until chlorinated hydrocarbon insecticides were introduced. Today, this method is limited —by expense—almost entirely to single trees grown in home gardens.

Before the synthetic insecticides were introduced, many fly control experiments were carried out by means of bait sprays. Inorganic insecticides, such as cryolite, lead arsenate, and barium fluosilicate, were used with the addition of 10 per cent. sugar or molasses as a fly attractant. These baits had many disadvantages, however. Poisonous residues were a danger to people eating the fruit, since the latter had to be treated shortly before harvest; the trees often showed burns, and it became necessary to repeat the treatment many times in order to ensure complete protection. Of the inorganic materials, only cryolite remains in use, as it has low human toxicity; its persistence, however, is of short duration.

**Chlorinated Hydrocarbon Insecticides:** A considerable amount of experimental work has been carried out with chlorinated hydrocarbon insecticides in Israel since 1946 by Schweig, Avidov and Swirsky, Greenberg, Georghiou, and others.

The official recommendations of the Plant Protection Department (Israeli Ministry of Agriculture) for the 1957 season were as follows :—

*Autumn Sprays* (September–October): Dieldrin 750 grams active material per dunam, or a concentration of 0.1 per cent. active material; or DDT 1,500 grams active material per dunam or a concentration of 0.2 per cent. active material. (One dunam = approximately 0.25 acre.)

*Spring Sprays* (March–April): The recommendations are as for the autumn, but stress is put on the use of methoxychlor since this is the season when citrus flowers bloom, and these are widely visited by bees, to which methoxychlor is not toxic.

(With regard to the dosages of insecticides recommended above, there is some evidence that dieldrin will effectively control the fly at considerably less than half the necessary dosage of DDT or methoxychlor.)

On apricots, peaches, figs and sub-tropical fruit one treatment of dieldrin is not enough since the growth of the fruit during the ripening period necessitates at least two sprays to ensure complete coverage. The last, within two weeks of harvest, endangers the safe use of the fruit; dieldrin can therefore only be used for the first spray. On the other hand, three or more applications of methoxychlor are required, which is expensive.

The successful tests carried out in Florida, which included the control of adults emerging from the pupae in the soil, by soil treatments with dieldrin, have aroused interest in Israel, and work on these lines will be carried out.

**Toxicity to Parasites and Predators:** The use of chlorinated hydrocarbons has caused difficulties by upsetting the balance between the black scale, *Chrysomphalus aonidum*, the chief enemy of citrus, and its predators and parasites, the most important of which, the ladybird beetle, *Chilocorus bipustulatus*, is generally killed by chlorinated hydrocarbons. Rivnai claims that dieldrin is not active against ladybird beetles in general, and especially *Chilocorus bipustulatus*, whereas DDT and, particularly, methoxychlor are very toxic to this scale predator.

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# Growing Sisal in East Africa

*Sisal planted in double rows.*

by **H. Sandford,** *Shell Chemical Co. Ltd. Formerly Agricultural Officer, H.M. Overseas Service, Tanganyika*

Sisal was first introduced into Tanganyika by a German, Dr. Hindorf, in 1893, when he imported a number of plants from Mexico. A few years later planting was carried out in Kenya, and today there are over 250,000 acres planted in the Colony. In Tanganyika, where more than 600,000 acres have been planted, sisal is one of the territory's major industries, with an export value of over £10 million, and almost a third of the employed population is to be found in the industry.

Sisal will grow under a wide range of conditions, extending from the highlands of Kenya to the dry humid coastal plains. The plant has remarkable drought-resisting powers, which makes cultivation easy, and it will grow in semi-arid areas which are practically useless for any other form of agriculture.

The use of agricultural chemicals in the sisal industry is at present limited by the low price of sisal fibre. First quality fibre now sells at £73 per ton, compared with a record price of some £250 about five years ago.

However, as will be shown below, research has proved that the fertility of the soil can be maintained, and sisal yields markedly increased, by the application of sisal waste, lime and nitrogen, though the precise economics have yet to be determined on an estate scale. Plantation managers are beginning to use aldrin and dieldrin against sisal weevil and it should not be many years before these control measures are adopted as routine practice. Yields are highly correlated to the number of plants per acre, and if weevils are present in large numbers the plant population may be reduced by as much as 40 per cent., with a consequent fall in production of about the same order.

Herbicides and arboricides are not yet in common use, but a considerable increase in demand during the next few years is to be expected, as labour for hand weeding becomes more difficult to obtain.

Sisal (*Agave sisalana*, Perrine), is a desert plant and its leaf arrangement is that of ascending spiral whorls of leaves around a short, squat stem or bole. The leaves are so arranged that rain is funnelled down the blades on to the ground around the base of the plant, where it is readily absorbed by the prolific surface roots and stored in the fleshy bole and leaf butts. The plant will grow in areas of low rainfall of 20 in. or less, but it will respond well to better moisture conditions. Sisal grows best in calcareous soils; under acid conditions it is liable to develop such disorders as chlorotic leaf mottle, purple leaf tip roll and tip wither.

*The head, greatly magnified, of an adult sisal weevil* (Scyphophorus acupunctatus).

Sisal flowers only once during its lifetime—about seven years—after which it dies. The inflorescence (' pole ') gives rise to numerous bulbils which are collected and planted out in a nursery. About 18 months later these bulbils will be large enough for planting out in the field, which will generally have been roughly cleared of bush and ploughed with a disc or stump-jump plough. Approximately 2,000 plants per acre are planted by hand in double rows, with a four-yard lane between each double row to allow access into the field.

Sisal should be ready for harvesting about two-and-a-half years after planting out in the field ; the lower leaves are then cut by hand every 12–18 months and taken to the factory for decortication. Only about 3.5 per cent. of the total weight of the leaf is extracted as fibre ; if the remaining portion of the leaf, known as ' sisal waste ', is returned to the land it acts as a valuable manure, but there are many physical difficulties in doing this economically and as a result the vast majority of estates do not manure their land at all. On many estates on which the soil has been ' mined ' in this way since the turn of the century the yields are very low, and a few estates may well go out of production in the near future unless adequate manuring is carried out.

Experiments have shown that sisal responds well to nitrogen, particularly on the less fertile soils of Tanganyika ; not only does nitrogen considerably increase yield, but it also brings the crop into cut a good deal earlier. On poor land it may be as long as four years before the first cut can be taken, whereas with adequate manuring with sisal waste and nitrogen this period can often be reduced to two-and-a-half years, thereby giving a quicker return and saving money on weeding costs and other cultural operations. Sisal receiving nitrogen may, in fact, ' pole out ' a year earlier than it would without nitrogen, thus giving a faster turnover.

The effects of the application of lime and nitrogen are well illustrated by the results of a trial carried out at the Sisal Research Station, Tanganyika, in which lime was applied at the rate of 6 and 12 tons of ground limestone per acre, and sulphate of ammonia at 100 and 200 lb. N per acre.

*Fibre yields in tons per acre for a complete cycle of sisal*

| | Nitrogen | | |
|---|---|---|---|
| | No | N1 | N2 |
| Liming Lo ... ... | 4.4 | 4.4 | 4.4 |
| L1 ... ... | 5.2 | 5.6 | 6.0 |
| L2 ... ... | 5.6 | 6.4 | 6.6 |

L.S.D. ($P = 0.05$) = 0.8 tons/acre

It should be noted that the acidifying effect of ammonium sulphate on the soil, to which sisal is intolerant, tended to counteract the beneficial action of the lime in this experiment.

Other experiments using many different kinds of nitrogenous fertilisers have given highly significant responses to both single and double rates of nitrogen, broadcast by hand down the rows a few weeks after the sisal has been planted out in the field and become established. These responses are most marked in the semi-arid areas in Central Tanganyika where it is advisable to give the plants an initial boost early in life. The placement of nitrogenous fertilisers has not shown any increase in yield over the hand broadcasting method.

The use of nitrogen fertilisers in bulbil nurseries has given variable results, but in combination with sisal waste mulch—an ideal manure for nurseries—it has given large responses and resulted in the plants being ready for planting out in the field six months to a year earlier than in the unmanured plots. It is important to time the application of the fertiliser correctly ; it should be broadcast at the

beginning and end of the long rains in April and May, with possibly a third application during the short rains in November.

Where sulphate of ammonia was applied at the rate of 100 lb. nitrogen per acre a year to the nursery trial for seven consecutive years, the bulbils died owing to the extremely acid soil conditions which developed. The best method is to apply a readily available nitrogenous fertiliser as a top dressing during rainy weather when it will be taken up rapidly; this will not only result in improved yields by increasing the number and length of the leaves per plant, but in addition the crop will have a much better appearance or bloom.

**Insecticides:** Aldrin and dieldrin have given good results in the control of sisal weevil (*Scyphophorus acupunctatus*). This pest, which until a few years ago was confined to the sisal growing areas around Tanga, has spread rapidly until it is now to be found throughout Tanganyika, but as yet it has not reached the Kenya highlands.

Eggs are laid at ground level at the base of the plants, and after hatching the larvae tunnel into the fleshy bulbils or boles of young plants. They are voracious feeders and owing to their prolific rate of breeding severe infestations can result in the death or distortion of up to 40 per cent. of the crop. Adult weevils are not responsible for any damage of economic importance, although while feeding they cause superficial damage to the leaves.

Nursery plants are particularly vulnerable to larval attack, especially in years of high rainfall, and it is important that control measures should be taken against them to avoid transplanting infested material into the field.

Trials at the Sisal Research Station, Tanganyika, indicate that the application of ½ lb. active dieldrin per acre is the best method of weevil control in nurseries. Six pints of 'Dieldrex' 15 are diluted in 90 gallons of water and sprayed at high volumes with a tractor mounted spraying machine or knapsack. By this method losses of bulbils have been reduced from 25 per cent. to less than 5 per cent. at a cost of about £1 per acre. One spraying at these rates is sufficient to give adequate control if the application is made shortly after planting, and when the top soil is dry. Spraying before planting and six months after planting has been ineffective.

'Dieldrex' 15 can also be used at the above rates for spraying transplants in the field, but consistently better results have been obtained from the application to the planting holes of aldrin wettable powder, which may be due to rapid weathering of the 'Dieldrex' 15 under wet weather conditions. Small cup-shaped holes about 3 in. deep are dug for the transplants, and into each of these 40 per cent. aldrin wettable powder mixed with 12½ times its own weight of diatomite (or 25 times its own weight of ground limestone) is 'peppered' before planting; 15½ lb. of the aldrin/diatomite dust are required per acre. The

*Damage done to a sisal transplant by larvae of* Scyphophorus acupunctatus.

quantity of dust applied in each planting hole is small, and to ensure that the aldrin is evenly distributed it must be intimately mixed with the base.

Results of a trial carried out in 1955 are as follows:

| | *% destroyed or weevil damaged plants* |
|---|---|
| Control... ... ... ... | 12.1 |
| 'Dieldrex' 15 spray ... ... | 13.3 |
| Aldrin w.p. dust ... ... | 0.6 |

The results of the dieldrin spray were disappointing on this occasion and were probably due to wet weather during application.

As sisal plants 'mature' they become increasingly resistant to weevil attack, until by the time they are about two years old they are unlikely to be seriously affected. If

an outbreak occurs in the field, it is best dealt with by spot spraying of infested plants. The presence of weevils can generally be detected fairly easily as the main spike becomes distorted, leaning over to one side; the plant can also be inspected for adult weevils, which feed on the leaf butts.

When spraying young plants, advantage is taken of the leaf arrangement, so that the liquid is funnelled down the leaves to the base of the plant, where a high concentration of the chemical settles on the soil and kills any weevils migrating from other plants. The best method of applying dieldrin is to remove the jet from a knapsack sprayer and pour a small quantity of the liquid over each plant; alternatively, two lances can be fitted to the rear of a tractor-mounted sprayer, after removing the jets, and a small amount of spray released over each plant by two operators. Results of a recent trial in which transplanted bulbils were sprayed once with dieldrin are as follows:

| | *Sprayed* | *Unsprayed* |
|---|---|---|
| Fibre yields (tons per acre) | | |
| 1st and 2nd cuts ... ... | 1.47 | 1.15 |
| % missing plants ... ... | 1.2% | 16.1% |

Aerial spraying has been found to be ineffective, as the chemical is scattered over a large area and is not concentrated round the base of the plant, where it is required for optimum results.

If aldrin dust is used at planting time it will usually protect the plant for the rest of its life, and spot spraying with dieldrin at a later date will not generally be necessary. The aldrin dust method is not only simpler but is also slightly cheaper, and is therefore to be preferred; the dieldrin spot spraying method finds its main use in areas where weevil is not a serious problem, and it is only necessary to keep small infestations in check.

**Herbicides:** The use of herbicides in sisal cultivation is still in the experimental stage, and their role in the future will probably be that of aiding rather than replacing established hand and mechanical methods of weed control. The growth of sisal, both in the field and in the nursery, is greatly suppressed by weed competition; in the case of field sisal, the first two or three years are the most crucial.

Although experiments have shown that yields can be increased by as much as 20 per cent. by clean weeding, it is essential that the crop should be grown in conjunction with some form of vegetable cover for soil protection, and to prevent erosion. Labour gangs are usually unable to keep pace with weed growth during the rains, and it is at this period in particular that herbicides are most useful.

In bulbil nurseries eight to 10 hand weedings are required if transplants large enough to be planted out in the field are to be obtained one year from planting; these operations are very costly and sufficient labour is seldom available. The application of 20 oz. acid equivalent per acre of 2,4-D or 25 oz. a.e. per acre of MCPA, applied as a post-emergence spray to germinating weed seedlings, has given good results in the control of many common species, including *Asystasia gangetica*, *Tridax procumbens*, *Commelina benghalensis* and *Euphorbia hirta*. Hormone weedkillers used at these rates sometimes cause distortion of the main spikes, but the set-back is purely temporary.

As grasses are generally more troublesome in nurseries than broad-leaved weeds, a pre-emergence application of TCA at 20 lb. per acre, or dalapon at 5 lb. per acre, before the bulbils are planted is often advisable. In order to avoid damage to the bulbils it is necessary to wait at least a fortnight after the application has been made before planting. The direct application of either TCA or dalapon to either nurseries or field sisal is not recommended as it results in severe leaf scorch and dieback. PCP is also lethal to growing bulbils when sprayed directly on to them.

In trials, the application of TCA at 20 lb. per acre before planting, followed by a post-emergence application of 2 pints per acre 2,4-D after planting, gave an 86 per cent. reduction in weed growth, and the number of hand weedings required was also reduced considerably.

In field sisal the problem of chemical weed control is very much more difficult as the crop is generally planted in dry weather. In any case, the majority of the weeds are grasses, and TCA cannot be used as a post-emergence treatment.

MCPA or 2,4-D can be used to good effect to control *Mucuna pruriens* (Buffalo Bean) in field sisal; this is a particularly unpleasant weed as the hairs on the seed pods cause intense irritation on contact with the skin, and labourers frequently refuse to cut sisal in fields badly infested with it.

Mature sisal fields are only weeded once a year before cutting, with the result that bush and small trees become widespread. Furthermore, during the preparation of the land before planting, tree roots and stumps are often left in the ground, and they regenerate rapidly. Many of the common species can be killed by the application of 0.5 per cent. 2,4,5-T ester formulations in diesel oil, or a combination of 2,4,5-T and 2,4-D (such as Shell Brush Killer). An effective and economic method of application is to cut the bush back to within a few inches of ground level and paint the solution on to the stems with a brush.

Looking to the future, it seems probable that sisal cultivation will eventually be revolutionised by a development of great importance: the breeding at the Sisal Research Station, Tanganyika, of a hybrid which yields over twice as much fibre as the normal sisal plant. When this hybrid becomes available for estate planting it should be possible to produce the same quantity of fibre as now from half the present acreage. This will necessitate intensive methods of cultivation with increased use of agricultural chemicals.

# Spraying by Helicopter in New Zealand

*by* **E. C. S. Little,** M.SC.

*The author has recently returned to England from New Zealand, where he played an active part in developing the technique of aerial spraying by helicopter.*

*A Bell helicopter landing at the loading site, near Wanganui, Northern Island, to replenish with 2,4,5-T. It has been spraying gorse on the hillsides in the background.*

The first impression of a visitor flying over New Zealand is of an expanse of hills, smooth and rolling or steep and rugged, stretching from horizon to horizon, and he sees that vast areas are green—green with grass. Dotted over this wrinkled landscape, with darker patches here and there of the remains of the original forest, are the white specks of sheep or the brown and black dots of cattle.

In the valleys and occasional plains are richer, more closely subdivided farms with milking sheds and silage stacks. But the farming is still one of grassland. For this 31 million acres of pasture is the principal crop of New Zealand, and the 40 million sheep and 6 million cattle which graze on these acres yield the wool, meat and dairy produce which is the main source of the wealth of the country.

The rainfall and climate make it possible to grow good grass on the hills—even on very steep hills. But like any other crop, grass, if it is to be profitable, has to be fertilised, well managed and kept free of pests. There is also in New Zealand the constant natural tendency for the hills to revert back to the vegetation which had always covered them—a dense rain forest, which the pioneer farmers had cleared with axes, fire and grubber. Much of the hill country is too steep for machines, and often too steep even for horses, so that fences, fertiliser, seed, stock, food—everything—had to be taken up by manual labour in the face of such obstacles as gullies, swamps and remnants of bush. The advent of the aeroplane as a farming tool, however, changed the situation rapidly.

The first and most obvious use to which the aircraft and trained pilots available after the last war could be put in agriculture was the spreading of fertiliser. The key to intensive grass production is nitrogen, and in New Zealand the key to nitrogen is clover. But clover requires adequate phosphate, a mineral in which most New Zealand soils are deficient. Once Tiger Moths were put into agricultural service, it was only a few years before the problems involved in distributing from the air thousands of tons of superphosphate on to the hills were overcome. The response of the pastures was excellent and before long numerous aerial top-dressing companies were operating. They soon began to seek other outlets for their equipment and men.

The sowing of seed and dropping of fencing materials and stock feed from the air became feasible : none of these operations required precision flying (because only reasonable accuracy on to the target was required), and it was practicable to fly at a safe height over the ground. In addition, the minimum working speed of fixed-wing aircraft—about 70 m.p.h.—was not too fast.

With the rapidly increasing fertility of the hills, weeds which were on the fertile low-lying land—and relatively easy to deal with by ground machinery—began also to invade the steep and inaccessible pastures. Thistles were the worst of these weeds, building up into vast, dense stands which covered acres of useful grazing. The most aggressive thistles are *Carduus tenuiflorus* and *Silybum marianum* (variegated).

The application of weedkillers such as 2,4-D and MCPA can be carried out accurately by ground spraying equipment without great difficulty, but to spray these chemicals from the air in sufficiently small amounts of water to be economic is a different proposition. Experiments soon showed, however, that it could be done fairly effectively, and at moderate cost, by Tiger Moths fitted with tanks and spray booms in place of the fertiliser hoppers which had been employed for top dressing. Where the work was on fairly easy country, free from such obstacles as trees and power lines, fixed-wing aircraft were put into operation for much of the thistle spraying work. Oil had to be used as a diluent for the herbicides, because water evaporated too rapidly, but as little as 4 gal. per acre proved sufficient.

**Introduction of Helicopters :** The first agricultural helicopter was introduced in 1955. This was something of an adventure, because such machines were—and still are—very expensive. But it soon became clear that this type of

*A Hiller helicopter spraying 2,4,5-T on a steep, gorse-covered hillside. It is flying at about 25 m.p.h. as close to the target as possible.*

aircraft was well suited to the work to be done.

Where the helicopter lost on costs per hour compared with the Tiger Moth (about £40 as against £14) it gained by doing more accurate and, consequently, more effective work. However difficult the topography, the helicopter, working at about 25 m.p.h., can fly close to the ground, and, when using a fairly coarse spray, will deliver most of the herbicide on to the weeds below. As there is less evaporation and less drift than from fixed-wing aircraft, water can be used in the spray. A vertical take-off machine also has the great advantage that it does not need a prepared landing site and can therefore refill alongside or within the target. This reduces waste flying to a minimum, speeds up the job, and enables the farmer to brief the pilot accurately and continuously.

**Gorse :** The most serious weed problem in New Zealand is gorse (*Ulex europeaus*). This prickly shrub, which was deliberately introduced into the country a hundred years ago to provide an easily grown sheep feed on the hills, rapidly established itself and became so widespread that it now occupies hundreds of thousands of acres. For the control of gorse, the introduction of the herbicide 2,4,5-T provided a great advance over repeated firings and manual grubbing. With ground and hand spraying equipment much useful work had been done and it became very interesting to see whether a helicopter could do as well as ground machinery. The main difficulty to be overcome was the volume of water which had hitherto been found essential to cover the dense canopy of vegetation, which is often up to 12 ft. high. Usually 400–600 gal. per acre had been found necessary—a volume quite uneconomic for aerial application. Oil is not a satisfactory diluent for herbicides used against gorse, and water must be used : the use of fixed-wing aircraft for this purpose is therefore not feasible.

With a helicopter, a series of trials on hill country gorse were made with varying amounts of 2,4,5-T (4–8 lb. per acre), water and wetting agent. Treatments were also made at different seasons, and the observation of the trials is still in progress. Coverage and penetration were tested by using strips of paper impregnated with dry crystals of a water-soluble dye. Droplets falling on the paper dissolve the dye, leaving permanent marks.

As yet, definite conclusions are difficult to make. It seems that four overlapping passes totalling 60 gal. per acre with 4 lb. 2,4,5-T gives satisfactory coverage, as all the plants in the target change within a month to an orange-brown colour all over. The canopy withers back from the tips and lets in light ; this allows some grass to grow and gives room for stock to forage for the new herbage ; these, by their treading, further open up the area.

In some cases most of the gorse plants never recovered, but gradually dried up and collapsed. In many other cases, after six to nine months fresh shoots sprouted from the main stem, and unless further action was taken, the plants would completely recover and reoccupy the area. Further spraying, crushing with stock, or careful firing are methods which can consolidate the advantage gained from the first spraying.

It seems probable that there is some combination, as yet unknown, of spraying technique, state of activity of the gorse, climate, and perhaps soil type, aspect, and other ecological features, which have to be exactly right if complete success is to be obtained. Perhaps a new herbicide, more potent than 2,4,5-T, and effective under more general conditions, would prove to be the answer to the gorse problem.

**Other Woody Weeds :** There are other woody weeds, however, against which 2,4,5-T seems to be adequately effective.

Helicopter spraying of broom (*Cytisus* spp.), carried out in the same way as for gorse, is fully effective. Some thousands of acres in the thermal regions, where the shrub flourishes on pumice, have been cleared. The colour change, as a response to 2,4,5-T, from dark green to a purplish tint can be startling. Under normal conditions a pilot can treat 10–15 acres an hour : a tremendous advance on the previous rate of 10–15 man-days per acre.

Manuka or ti-tree (*Leptospermum* spp.), the shrubby precursor of native forests, is also fairly readily killed by 2,4,5-T. Willows (*Salix* spp.) are more difficult to kill. These trees are serious weeds over thousands of acres of swamps and rivers. Though they are susceptible to 2,4-D, it has so far proved possible only to destroy them by ‘frilling’ the bark and injecting the weedkiller. Their habitat, however, makes work of this type very difficult. Many of the difficulties of drainage and river control boards would be removed if an aerial attack on willows were effective. Some trials by air have been made, but so far with indifferent results : defoliation follows spraying but regrowth occurs later. A new approach, with the development of a specialised technique, seems necessary to cover adequately the intricate maze of branches, trunks and foliage which constitute a typical willow infestation.

**Forests :** The large forests of exotic conifers which are a feature of the central part of the north island, and to a lesser extent of other parts of the country, provide an interesting weed problem. When after about 20 years of growth the trees are felled and removed, a fresh crop of seedling pines

springs up. But so also do the seedlings of many native shrubs and trees, which often overwhelm the pines and reduce the yield of the second crop. Workers on the ground are hampered by the tangled mass of limbs and stumps left from the felling operations.

In an effort to control the woody weed seedlings a trial was carried out with a helicopter, spraying total weed-killers. With sodium chlorate, preliminary results showed that it was possible to severely check or even kill the competing weeds without causing the pine seedlings more than superficial damage. Sodium arsenite was less selective, and killed or severely damaged everything.

This interesting result was used in a further experiment to test the possibility of cutting tracks through mixed vegetation from the air. Using five specially designed jets fitted to the helicopter spray boom which, at 25 m.p.h., 30 ft. above the ground, each gave only a 2-ft. wide swath, lines of concentrated sodium arsenite were sprayed on to dense scrub. Within two or three weeks clearly defined tracks had been formed. Such tracks could be used for access purposes, or as planting lines after rain had leached the herbicide away.

**Insecticides :** Most aerial spraying in New Zealand is against weeds, but insects have also been attacked from the air. The main pests successfully controlled have been leaf-eating caterpillars in forests and pasture-destroying caterpillars—the so-called army worms (*Pseudaletia* and *Persectania* spp). [The control of these pests with dieldrin was discussed by B. B. Watts in *Shell Agricultural News*, Vol. 2, No. 2, December 1957, pp. 11–13.—Editor.]

Trials have also been started against the grass grub, the larva of a beetle, *Costelytra zealandica*, which by its widespread destructive feeding on the roots of pasture plants has earned the title of the most serious insect pest in the country. DDT, if applied so that it can reach the soil, is effective. It is usually applied as a dust at the rate of 2 lb. per acre. Aerial trials spraying DDT on to pastures eaten bare by sheep have been carried out and are still being assessed.

All these activities have not been without their setbacks. In difficult flying conditions of mountainous country, with gusty winds and many flying hazards, accidents were inevitable, and agricultural flying under these conditions demands a high degree of skill on the part of the pilot. Fortunately, helicopters can be force-landed with a high measure of safety to the pilot, and the use of aqueous rather than oil sprays is a valuable safety factor ; but the machine itself is fragile and the slightest damage usually results in expensive replacements of parts.

A typical accident is caused by landing tail down. The tail rotor hits the ground, the tail boom is bent up and is then cut off by the main rotor. Such heavy damage is costly in terms of both repairs and of loss of working time.

However, the steadily expanding fleet of helicopters and fixed-wing planes engaged in spraying show that this form of aerial farming is well established. With improvements to simplify and cheapen helicopter design, further expansion of aerial application is to be expected. In the foreseeable future aerial spraying may be able to compete effectively with work by ground equipment, particularly where it is necessary to treat large areas in a short time, or where wheel damage to water-logged soil or to valuable crops must be avoided.

# Dollars for W.H.O. Malaria fund

Seven million dollars have been contributed by the United States Government to the World Health Organization and the Pan American Sanitary Organization to further the work of these bodies in assisting governments throughout the world to eradicate malaria.

Malaria infects some 250 million persons each year, and is still the most prevalent and costly disease in many countries. Because of the social and economic importance of this disease, concrete planning for its control (by destruction of the mosquito vectors with residual insecticides) was initiated some years ago. At its 14th Conference in Chile in 1954, the Pan American Sanitary Organization launched the first programme of this kind in a major area of the world, aimed at the eradication of malaria from the Americas.

In a similar action taken in Mexico in 1955, the Eighth World Health Assembly extended the eradication programme to cover the whole world. The special malaria eradication funds were set up outside the regular budgets of W.H.O. and P.A.S.O. to help meet the considerable immediate cost of this work. The organisation invited voluntary contributions to these funds, over and above the regular, assessed quota payments made annually by their member governments.

During their 21st session, held in London in January, 1958, the executive board of W.H.O. noted the progress made in the malaria eradication programme (which is intended to cover a period of five years) and appealed to governments, industry and other organisations, and to individuals to contribute to the World Malaria Fund. At the time of the appeal the fund's resources ($5,111,700) were only sufficient to cover the cost of the programme in 1958.

Eighty-eight nations are members of W.H.O. Membership of the P.A.S.O. includes the 21 American republics, and France, the Netherlands and the United Kingdom on behalf of their territories in the Western hemisphere.

# TRACTOR STABILITY

## *How to avoid accidents*

There are two aspects to be taken into account when considering the stability of tractors. In other words, to stay upright, the tractor has to abstain from either rolling over sideways or standing on its nose or rear.

**Transverse Stability:** The factors involved in transverse, or lateral, stability are comparatively straightforward (see first diagram). The centre of gravity of the tractor is at a certain height above the ground, and listing of the tractor will reduce the 'arm' or leverage of its weight tending to keep it upright transversely. The lower the height of the centre of gravity and the greater the gauge of the wheels or tracks, the greater the stability of the tractor. Tracklaying machines as a class are superior to wheeled tractors in this respect. Apart from transverse inclination, any force acting athwart the tractor will also reduce the effectiveness of the righting couple. Side-draught will do this, or the centrifugal force that operates when a sharp turn is made at high speed. It is particularly dangerous to turn sharply uphill after running across a slope.

**Longitudinal Stability:** The development of conditions of longitudinal instability is, perhaps, more likely to cause an accident to a newcomer to tractor operation. First, let us look at wheeled tractors. Here, two possibilities must be considered: back-somersaulting and forward-somersaulting.

### OVERTURNING TRACTORS

A recently published analysis of fatal accidents on farms in England and Wales during 1956 shows that the greatest single cause of death was the overturning of tractors. This form of accident, in fact, accounted for over 20 per cent. of all deaths resulting from accidents in agriculture, as the following table shows.

In view of the considerable danger to life of overturning tractors, the accompanying article on tractor stability is of particular interest. It is reproduced from the book, *Know Your Tractor*, published by The Shell Petroleum Company Limited in 1955.

### CAUSES OF FATAL FARM ACCIDENTS

### ENGLAND AND WALES, 1956

| | |
|---|---|
| **MACHINERY** | |
| Tractors: | |
| (*a*) Overturned ... ... ... ... | 21 |
| (*b*) Overturned—silage heaps ... ... | 6 |
| (*c*) Falls from ... ... ... ... | 10 |
| (*d*) Various ... ... ... ... | 6 |
| Implements and machines (including self-propelled): | |
| (*a*) Power take-off shaft ... ... ... | 2 |
| (*b*) Various ... ... ... ... | 13 |
| Fixed and portable machinery (including power tools) ... ... ... | 9 |
| Lorries and cars ... ... ... ... | 3 |
| Electricity ... ... ... ... ... | 4 |
| Burns and scalds involving machinery ... | 2 |
| | 76 |
| **OTHER CAUSES** ... ... ... ... | 51 |
| TOTAL ... ... ... ... ... | 127 |

Back-somersaulting is rotation rearwards of the body of the tractor about the axis of the rear wheels or about the points of contact between the rear wheels and the ground. Whatever the forces tending to cause a back-somersault, the only force tending to prevent it is the moment of the weight of the tractor about the potential pivot point. This means that if a back-somersault should develop, the effect will be progressive reduction of the correcting moment, since the centre of gravity of the tractor will move rearwards. Unless, therefore, the clutch is instantly disengaged, or an implement or other attachment acts as a sprag, violently accelerative overturning will take place and the driver will almost certainly be killed.

The simplest case of back-somersaulting is that when a wheeled tractor is bogged down by its rear wheels and the

operator tries to jerk the tractor forward in low gear. The danger then arises that the tractor body may simply rotate backwards as though its rear wheels formed a fixed pedestal. (In such circumstances, the operator should engage a high gear, with a small throttle opening, and should clutch in gently. If the front of the tractor starts to lift, he should clutch out at once. Where possible, it is advisable to *back out*. Maximum torque can then be applied to the back wheels with complete safety.)

The possibility exists that engine acceleration alone might be sufficient to lift the front wheels from the ground and cause back-somersaulting. A similar effect is very marked with a motor-bicycle. With a tractor it might contribute to overturning if the machine were going up a steep hill, or if it were carrying weight on a three-point linkage, or both.

The state of affairs in the matter of longitudinal stability becomes complex when the tractor is under load at the drawbar. Every tractor operator should understand that the hauling of a load by a tractor causes a transfer of weight from front to rear—from the front wheels to the back wheels in wheeled tractors and from the front end to the back end of the tracks in crawlers.

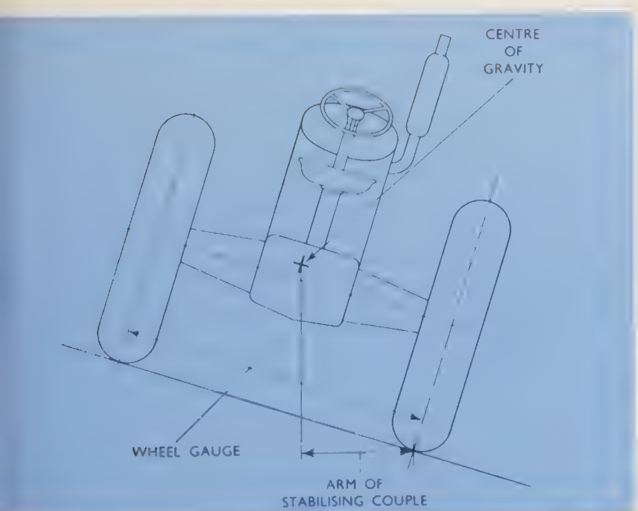
This weight transfer varies with the tractive effort and is attributable to the moment of the load at the drawbar about the point of contact between the rear wheels and the ground—in other words, the drawbar pull exerts leverage which tends to make the tractor ‘ rear ’ and may promote a back-somersault. The position of the hitch point or drawbar pivot along the length of the tractor has no bearing on whether the front wheels will lift, but the height of the hitch is important : longitudinal stability is increased by using the lowest possible drawbar height. It depends also on the wheelbase, increasing as the wheelbase increases.

If the shift in weight from front to rear becomes large enough, the front wheels will be completely relieved of weight. The tractor will then be impossible to steer and any further increase in load will make it rear, as shown in the second diagram. Referring to the diagram, a condition of stability is that $Wb$ must exceed $L\ (R-x)$. Rearing can occur however low the hitch point, if the load is great enough, but the load required to rear the tractor will increase as the hitch point is lowered.

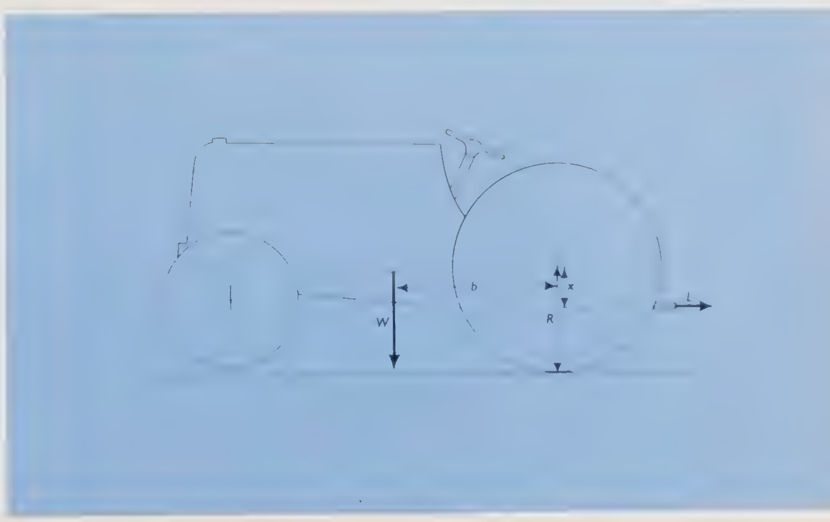
It is fallacious to suppose that rearing cannot occur so long as the line of action of the load passes below the axis of the rear wheels. Note that when the line of action of the load is inclined downwards the result is that the distance $x$ is reduced and the couple tending to rear the tractor is increased. When the line of action of the load passes above the axis of the rear wheels, $x$ becomes negative and a particularly dangerous condition arises. There is sometimes advantage in downward inclination of the hitch when pulling a heavily laden wagon, as it makes it easier to move the load, but great care is then needed to avoid rearing.

The tendency of a tractor to rear is increased when it is pulling a load uphill because the ‘ arm ’ of the longitudinal ‘ righting couple ’ due to the weight of the tractor is reduced. The operator should always take care that a dangerous distribution of weight cannot develop, and should if necessary ballast the front end of the tractor to keep it down. Allowance must be made for the steepest gradient on which the tractor is to work. Great care is necessary where gradients are locally increased by ground undulation, holes and so on, or where there are dense growths such as gorse.

Front-ballasting is largely confined to wheeled tractors, in which the weight is chiefly concentrated on the back wheels, to give maximum adhesion, and the built-in weight




*Transverse stability of tractor.*




*Longitudinal stability of tractor.*

on the front wheels may be little more than is required normally for steering and stability. For operation with high tractive effort, or on hillsides, the weight on the front wheels may be inadequate, in which case metal blocks may have to be attached to the front end of the machine or to the front wheels. With a wheeled tractor a certain minimum pressure between the front wheels and the ground is, of course, essential for steering: as indicated, excessive shift in weight from front to rear during operation may make the tractor difficult to control.

In practice, the tendency of a loaded tractor to back-somersault will depend partly on what it is pulling and how the load is attached, apart from the height of the hitch and design factors such as wheelbase, position of centre of gravity, and so on. In general, back-somersaulting will be more likely to occur with wheeled trailers, or implements able to roll backwards readily, than with implements such as a mouldboard plough. The form of attachment comes into the matter in that a very robust linkage or projecting drawbar may resist collapse and so prevent disaster. Hydraulic safety devices may also, of course, come into play.

Other factors affecting back-somersaulting are the height of the centre of gravity and the tendency of the rear wheels to slip. The higher the centre of gravity the sooner will a vertical line through it pass behind the area of contact between the rear wheels and the ground. Slip may tend to prevent somersaulting, but in some cases it may promote it, by enabling the rear wheels to dig a hole for themselves in which they become fixed.

**Forward Somersaulting:** Consider now forward-somersaulting. This is only liable to occur when the tractor is going fast downhill without load or on light load, particularly when followed by a free-running implement or trailer. If the front wheels drop into a hollow there will be a sudden drop in the longitudinal ‘righting couple’ about their point of contact with the ground. The momentum of the tractor, or ‘overrunning thrust’ referred to it from the implement or trailer, may then cause overturning. The effect may be promoted by sharp application of the brakes. Overrunning thrust is especially dangerous when the tractor is changing course, as there is then a tendency for the tractor to be swung sideways and rolled over.

**Crawler Tractors:** A crawler is more stable than a wheeled tractor, because of its greater area of contact with the ground and its lower centre of gravity. Another factor making for stability is as follows. The tractive effort of a crawler will be reduced if the grousers are not all at work, and this will be so if there is an increase in ground pressure from front to rear. It is therefore advantageous for the weight of the machine itself to be concentrated towards the front, so that longitudinal distribution of the ground pressure becomes more uniform when the tractor is hauling a load. Thus all crawlers are, by design, nose-heavy when stationary. The effect is also to counter rearing. For these reasons a crawler rarely requires front ballasting for stability. On the other hand, special care is needed to avoid forward-somersaulting when running light down steep hillsides.

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# Agriculture in Turkey — land of contrasts

*by* **T. N. Reid,** *Shell Chemical Company Ltd.* (*Formerly with The Shell Company of Turkey Ltd.*)

As a prelude to discussing modern agriculture in Turkey it is as well to look briefly at the past—for in the space of three decades the country has undergone a tremendous upheaval. In that time she has changed from a country of eastern culture to one of western outlook.

The change, however, is by no means complete and some of the remote areas are still as they were at the beginning of the century. In agriculture, particularly, change has been slow: indeed, it is only in very recent times that any radical changes have taken place at all.

Before the First World War economic progress in Turkey was handicapped by the legal and political system. Religion dominated the courts of law. The Sultan was supreme. Concessions were granted to foreign enterprises to such an extent that the Government was gradually weakened, increasing numbers of concessions becoming ever more onerous to the country.

Immediately after the First World War Mustafa Kemal—Ataturk—came into power, setting himself the extremely difficult task of clearing away the obstacles to economic progress. In the almost bloodless revolution which followed his assumption of power, the Sultan was deposed, the Caliphate (the office of supreme religious authority) abolished, and the law, education and dress were westernised.

**Turkey Divided:** Modern Turkey can conveniently be considered in two parts: the European side, Thrace, upon whose south-east point is situated Istanbul; and the Asiatic side, Anatolia, once known as Asia Minor. The division is that famous neck of water, the Bosphorus,

linking the Black Sea and the Sea of Marmara.

Thrace is relatively well suited to general farming. Anatolia has a large, semi-arid central plateau surrounded by mountains. South of this plateau lies a fertile delta region. West lies the Aegean area with a mediterranean climate. In the north the mountains drop sharply to the Black Sea, except for a narrow coastal strip with an almost tropical climate ; whilst in the east, where the mountains reach their greatest height (Mt. Ararat, 17,000 ft.), extensive grazing lands are located.

Statistics being, in Turkey, more or less an innovation, they are not very reliable and figures quoted in this article may not always, therefore, be accurate, but they can serve as a guide.

Turkey's total land area of 300,000 square miles is divided as follows :

| | |
|---|---|
| Meadows and pasture ... ... ... | 45% |
| Croplands, vineyards and orchards ... | 25% |
| Forests ... ... ... ... ... | 13% |
| Other classifications ... ... ... | 17% |

The soils are calcareous with frequently a high lime stratum from 6 to 18 in. below the surface. In certain parts of the plateau the salt content is too high for profitable cultivation. Erosion and denudation of forests has gone on through the centuries, leaving barren hills and mountains everywhere. On the plateau, however, this problem fortunately does not exist.

Climate and rainfall vary widely ; in general, the former is temperate. In the north-east the mean temperature varies from about 45° F. in winter to 70° F. in summer, compared with 30° F. and 75° F. in the central plateau. Annual rainfall ranges from 100 in. in the north-east to 10 in. on the plateau. The water problem is often acute and great plans exist for the harnessing of available rivers. At present, only 250,000 acres are irrigated, and this is by surface waters.

Turkey's population is around 24 million, with an average annual increase of 2 per cent. It is chiefly rural and agricultural, 75 per cent. of the population living in rural areas. Few workers are engaged in fishing or forestry. It is frequently assumed that nearly eight out of every 10 workers are engaged in farm work to produce the basic agricultural products necessary to give the country a minimum standard of living, but this is not strictly correct, since quite substantial amounts of produce are exported. This rural population is thinly scattered in some 35,000 villages, with poor, though improving, roads of communication.

**Farm Equipment :** Primitive tools and techniques are still used, while both expenditure and income remain correspondingly low. Wooden ploughs drawn by oxen, donkeys, camels and horses are often seen. Threshing both by oxen and flail is still widely practised. In 1949 there were 2,000 tractors. By the end of 1953, thanks largely to substantial loans from the U.S.A. under Economic Cooperation Administration, there were 35,000 tractors. In addition, combine harvesters, cultivators and other modern equipment is still being made available. Most of this up-to-date machinery is found on the State-owned farms and on a few large private farms in south and south-west Turkey. A scheme for seasonal loans of machinery to farmers by the State has also been introduced.

A wide diversity of crops is grown, ranging from winter

*Ploughing: old style and new in Turkey today.*

PHOTOS : PRESS OFFICE, TURKISH EMBASSY, LONDON

*A method of threshing still widely employed in Turkey. The man stands on a heavy sled which he drives over the corn to be threshed.*

PHOTO : PRESS OFFICE, TURKISH EMBASSY, LONDON

wheat to citrus, tea and cotton. Similarly, animals range from hardy highland cattle, sheep and goats to Indian water buffaloes and camels. Cereals form the main agricultural production and account for 84 per cent. of the tilled land. Production has made great strides over the past 25 years, so that Turkey, from being an importer, now holds a strong position in the world markets as a wheat-exporting country. Maize is also widely grown, but rice cultivation is limited to about 445,000 acres, which do not produce sufficient grain to meet the internal demand. The incidence of malaria has largely prevented further expansion.

**Export Crops :** Cotton, which was first grown in Turkey about a century ago, is undoubtedly the principal industrial crop, since it provides most of the raw material for the country's textile industry ; considerable quantities are also exported. The acreage devoted to this crop doubled between 1949 and 1952, and is now over $1\frac{1}{2}$ million acres.

The leading export is tobacco, a crop which has long held an important position in the country's economy. Produced mostly by peasant farmers, from some 301,000 acres, it is under State monopoly, the choicest variety being mainly exported to the United States. Production rose from about 61,000 tons in the years 1934–38, to a record level of 122,000 tons in 1953 ; since then it has fluctuated slightly. More than half the tobacco crop is grown in the Aegean region, where the leaf is light red or yellow ; there is virtually no petiole and the leaf has a high reputation for aroma and flavour.

The Turks are a sugar-loving nation, and considerable quantities of sugar are consumed. Vigorous encouragement by the State within the last two decades has increased the production of sugar from 97,000 tons in 1940 to something over 500,000 tons today. The whole of this production is from sugar beet. Thirteen processing factories are working, and a total of 18 are planned.

It is probably not commonly known that Turkey is the chief producer of hazel nuts, and this crop is of economic value to the nation. In fact, it is fourth only to cereals, cotton and tobacco. About half the output is consumed within the country, the balance being exported to Britain, the United States and Switzerland, where it is used in the confectionery industry. The filbert groves are concentrated on the Black Sea coast at elevations of about 1,000 ft.

**Fruit Production :** Raisins constitute another important crop for export. Eighty per cent. of the vines are found in the Aegean area, although some of the best varieties come from sheltered valleys in central Anatolia. The production of grapes is around 1,300,000 tons, but even this yield compares unfavourably with California, which has taken away some of Turkey's export markets.

Turkey is one of the world's chief olive producers, the annual output being about 300,000 tons from 855,000 acres. Olive oil is a staple part of the diet, and soap production accounts for quite a high proportion of the crop. Consequently, exports are small.

Figs are reported to have originated in the Aegean area, where some 370,000 acres are in production. Large-scale production of tea on the north-east coast line is a relatively new project : seed was originally imported from Darjeeling. Sesame is widely grown, and liquorice enjoys an export market. Almost every variety of fruit known to Europe and North America is grown.

**Livestock :** Although an appreciable number of animals are slaughtered for food, most are raised for other purposes. Sheep, of which there are about 20 million, provide wool for rug making and for the woollen textile industry. Some 10 million ordinary goats and 4 million Angora goats are raised for hair and milk. Mohair is largely exported. Oxen, buffaloes, donkeys, horses and camels are used as draft animals. There are but few herds of beef cattle. Whole milk marketing from goats, buffaloes and cows is largely unknown, but butter, cheese and yoghurt are extensively produced.

Today, the Turkish Government is fully alive to the need for agricultural development. Young men and women are now sent to America and Europe to study western farming methods and, with economic aid from the West, scientific workers and equipment have been obtained and research stations opened. Without doubt, agriculture in Turkey has a big future.

PHOTO: FARMERS WEEKLY, JAMAICA

## Nematodes controlled in Sugar Cane

A striking example of the increased crop growth which may follow nematode control. This photograph, taken on the Worthy Park Estate, Jamaica, B.W.I., shows, on the left, sugar cane growing in soil which had been fumigated with D-D Soil Fumigant (dichloropropene-dichloropropane mixture); the cane on the right is the same variety and was planted at the same time—in untreated soil. The soil fumigant was applied on the ridge (injected into the crown and 1 ft. on either side) at the rate of 200 lb. per acre. The cane is planted on ridges 6 ft. wide.

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